TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

No. 114

# SUPPLEMENTARY REPORT OF OIL SCRAPER PISTON RINGS.

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1. Due to the unfortunate accident noted in paragraph 15 of Technical Note No. 88, whereby aluminum particles were distributed throughout the lubricating system of the oil-scraper ring engine, the results of the seventy-five (75) hours and fifty-five (55) minutes of operation were inconclusive, so far as accurately estimating bearing life is concerned. To supply this deficiency, this report, based upon the operating record of this engine subsequent to the overhaul necessitated by this accident, is herewith submitted.

Procedure:

2. This engine, after the overhaul - consisting of the cleaning of the entire lubricating system, the removal of aluminum particles from the surface of the babbitt of the main bearings, and the fitting and installation of new crank-pin bearings - was installed on a torque stand and used for incidental tests. The majority of these tests were to determine the characteristics of the engine when fitted with various types of manifolds; thus imposing operating conditions no more severe than those encountered in normal service. For a total of approximately five (5) hours, however, the engine was used on runs for the development of glass spark plugs, which pre-ignited badly even in this low

* Continuation of Technical Note No. 88.

compression engine; thus imposing the most unduly severe conditions of operation possible.

Results:

3. During the entire life of the engine (when equipped with oil scraper rings) of two hundred and sixty-two (262) hours and forty-eight (48) minutes, to date, the carbon deposits have been removed four (4) times; or an average interval between carbon removals of sixty-five (65) hours and forty-two (42) minutes. Except on the occasion of the last overhaul, the engine would have functioned entirely satisfactorily if it had been re-assembled without the removal of the carbon - the value of the above average interval between carbon removal is, therefore, doubtful and unquestionably too low. On the last overhaul, it was found that an accumulation of carbon had built up in the piston and ring oil grooves and in the piston ring gaps and grooves. These deposits had been unnoticeable on previous overhauls but would have caused trouble on this occasion if they had not been removed.

4. As shown by Table I, the valves have been re-ground three (3) times - giving an average interval between re-grinding of 87 hours and 36 minutes. On the first two (2) occasions the re-grinding of the valves was absolutely necessitated by the leakage through one or more valves, but the third re-grinding was not absolutely necessary, as no leakage past any of the valves could be discovered at the time of the last overhaul. As the engine was apparently functioning perfectly at this time, this

dis-assembly was caused only by the necessity for interchanging the cylinder banks from left to right, to bring the inlet valves to the outside of the engine for a continuance of the manifold tests. As these tests would be of considerable duration, it was desired to have the engine in the best possible condition - thus avoiding the necessity for overhaul during the progress of these runs, with the attendant possible chance for change in conditions which would effect the results. Although the valves, when tested with gasoline, showed absolutely no signs of leakage in their operating positions, it was found that, due to warpage of the seats and valves, they leaked badly if rotated on their seats. They were all, therefore, re-ground, although they would probably have continued to run in their operating positions for many more hours without leakage - thus indicating that the probable life of the valves between re-grinding is a mean between the two previous actually determined intervals of 106 hours and 45 minutes and 99 hours and 55 minutes, or a mean life of 103 hours and 20 minutes.

5. The list of replacement of parts shown by enclosure (a) is remarkably low and consists only of the following; one (1) double exhaust spring, one (1) main bearing bolt, six (6) connecting rod bearings, one (1) piston, one (1) piston pin stop (the three latter items being all necessitated by the pulverizing, and consequent distribution of the piston pin stop throughout the lubricating system), one (1) piston ring, (1) camshaft housing, and one (1) cylinder (this cylinder was rendered unsafe by the depth

to which the exhaust valve seat had to be reamed to true up).

6. Both main and connecting rod bearings were in remarkable condition at the time of the last overhaul, and showed no appreciable change in clearance from that with which they were originally fitted. No change was made or fitting found necessary, at this time, on any of the bearings. The bearings thus show a life, to date, of one hundred and eighty-six (186) hours and fifty-three (53) minutes for the connecting rod bearings, and of two hundred and sixty-two (262) hours and forty-eight (48) minutes for the main bearings (without fitting and with only the embedded aluminum particles scraped out at the end of the period covered by the report of Technical Note No. 88).

7. When the engine was dis-assembled after two hundred and sixty-two (262) hours and forty-eight (48) minutes of operation, the pistons and cylinders were found to be in the following condition: The oil film on both cylinder walls and piston skirts was ample. The appearance of the piston skirts differed in nowise from that of production pistons on dis-assembly after the first normal period of operation (i.e. - with the slight scores characteristic of aluminum pistons but without undue signs of wear). The piston and cylinder heads had exceedingly light carbon deposits (less than 0.010" in thickness) which were hard and dry, without the least sign of oil, and had more the appearance and structure of gasoline than of oil carbon. The cylinder bores showed a wear of from 0.002" to 0.003" at the combustion chamber end.

Conclusions:

8. The long life of the bearings - of one hundred and eighty-six (186) hours and fifty-three (53) minutes, and two hundred and sixty-two (262) hours and forty-eight (48) minutes, respectively for the connecting rod and main bearings - is remarkable in view of the average bearing life obtained at this laboratory, of from sixty (60) to sixty-five (65) hours for connecting rod bearings, and of from eighty (80) to one hundred (100) hours for main bearings. In this connection, consideration must also be taken of the fact that, after this length of service, these bearings are again going into service unchanged and without additional fitting. The conclusions, necessarily largely drawn from theoretical considerations (Technical Note No. 88) in regard to probable bearing life, are, therefore, amply substantiated by the above practical operating results.

9. The ample oil film existing on both piston skirts and cylinder walls, the excellent condition of the piston skirts, and the very slight cylinder wear due to the one hundred and eighty-six (186) hours and fifty-three (53) minutes of operation subsequent to the period covered by Technical Note No. 88 (making a total period of operation with these cylinders of two hundred and sixty-two (262) hours and forty-eight (48) minutes) certify to the entire adequacy of cylinder wall and piston skirt lubrication with scraper rings, and should dispel any fear that may have remained, in spite of the previous report, that the scraping action on the cylinder wall oil film would be too severe. In com-

parison to the slight wear (0.002" to 0.003") shown by these cylinders due to 262 hours and 48 minutes of operation, a wear of slightly in excess of 0.003" has been observed in the cylinders of several production engines at the end of fifty (50) hours of normal operation.

10. Aside from the substantial saving in oil consumption (previously reported, and the accuracy of which needs no substantiation) of approximately one (1) gallon per hour at the usual operating speeds, the longer main and connecting rod bearing life is a distinct economic advantage. The longer periods between disassemblies for carbon cleaning is also a distinct advantage from both an operating and an economic standpoint. It is well to bear in mind, in this connection, that the oil-scraper ring and the oil-drain hole piston are not the causes of this material increase in bearing life, but are merely the means to the end; the real cause is the ability to carry full oil pressure without fouling and oil pumping into the combustion chamber, which, in turn, is made possible by the oil-scraper ring and the oil drain hole pistons.

11. It is therefore again strongly recommended that the oil pressure relief valve of all aeronautical engines be set to discharge at not less than the pressure specified for full speed operation, at idling speed and that, in order to prevent excessive fouling with this oil pressure, and oil-scraper ring and oil drain hole piston be adopted as standard equipment.

Table 1.

Summarized Operation Log of Liberty Engine, Eng.#0925 fitted with Oil Drain Hole Pistons and Oil Scraper Piston Rings.

| Total Operating Time | Overhaul |
|---|---|
| 1/28/19 | Pistons chamfered at bottom ring groove, oil drain holes drilled, and oil-scraper piston rings made and installed. Valves ground. |
| 32 hr. - 45 min. | Both exhaust springs on #5L cylinder broken and replaced. |
| 47 hr. - 10 min. | One (1) main bearing bolt at generator end broken and replaced. |
| 75 hr. - 55 min. | Connecting rod bearing shells replaced and aluminum particles scraped out of main bearings (not necessary to actually refit bearings) due to wrist pin stop getting loose and hammering to pieces - thus distributing aluminum particles throughout the lubricating system. This piston and wrist pin stop replaced. Lubricating system thoroughly cleaned. Top ring #6L piston found broken and replaced. Carbon removed. Valves tested, found tight and therefore not re-ground (Overhaul A). |
| 106 hr. - 45 min. | Valves re-ground. Carbon removed (30 hr. 50 min. operation since last carbon removal. 106 hr. - 45 min. operation between valve grinding. 30 hr. - 50 min. operation since overhaul A). |
| 153 hr. - 32 min. | Camshaft housing broke at #3R exhaust rocker arm bearing. New housing installed. (77 hr. - 37 min. operation since overhaul A). |
| 206 hr. - 40 min. | Valves re-ground. Carbon removed (99 hr. 55 min. operation since last re-grinding of valves and removal of carbon. 130 hr. 45 min. operation since overhaul A). |

262 hr. - 48 min. Cylinders removed, to interchange banks, in order to bring inlet valves to outside of engine, for continuance of manifold tests. Valves tested with gasoline and found tight when in operating position, but leaked badly when rotated on seats. Hence, valve seats were reamed and valves re-ground. No. 2R cylinder was replaced because exhaust valve seat, in order to true up, had to be reamed so deeply as to make the cylinder head unsafe. No other replacements were found necessary. All bearings were found to be in excellent condition, and, therefore, were not refitted in any manner.

Since oil carbon had accumulated in the c[illegible] grooves in the piston skirt and piston rings on the gap ends of the rings, and in the bottom of the ring grooves, the pistons and rings were thoroughly cleaned and freed from carbon. The piston and cylinder heads had no oil on them whatever and the carbon deposits on these surfaces were very thin (less than 0.010") and were hard and dry, having more the appearance of fuel than of oil carbon. (56 hr. - 08 min. operation since last re-grinding of valves and cleaning of carbon. 186 hr. - 53 min. operation since overhaul A - life, to date, of connecting rod bearings).